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(54) METHOD OF HYDROFORMING TUBULAR MEMBERS

VERFAHREN ZUM HYDROFORMEN VON ROHRFÖRMIGEN BAUTEILEN

PROCEDE D'HYDROFORMAGE D'ELEMENTS TUBULAIRES

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Description

Background of the Invention

[0001] The present invention relates to a method of fabricating a tubular member having a variation in circumference or diameter along its length member used in constructing vehicle frames. More specifically, the present invention relates to structural members that are fabricated using hydroforming which are generally tubular and vary significantly in circumference, gage, or cross section along their lengths.

[0002] In many instances, it is necessary to create structural members such as frames or mounting components to provide overall support to other devices. This is particularly true in the manufacture and assembly of vehicles such as automobiles, trucks, sport utility vehicles and the like. Such a vehicle frame is shown in U.S. Patent No. 5,149,132 entitled "Split Rear Truck Frame" which is assigned to the assignee of the present invention and is incorporated herein by reference. Another example of such a truck frame and its related mounting structures can be found in U.S. Patent No. 5,308,115 entitled "Vehicle Frame With Overlapped Sections", also assigned to the assignee of the present invention and incorporated herein by reference.

[0003] A vehicle is assembled, at least in part, by constructing a frame and attaching components to the frame. Vehicle components may include the engine cradle, the suspension system, body panels, control arms, rear box load, cab, brake and fluid lines, and the like. The frame typically includes two generally parallel, spaced-apart side rails which run substantially the length of the vehicle. Cross-members span the distance between the side rails. Vehicle components are attached to the frame directly such as by bolting, riveting, or welding, or indirectly through brackets or other mounting structure.

[0004] Typically, components of these frames and structural members are manufactured by stamping plate steel onto desired configurations. These stamping or manufacturing operations require the use of very large presses which impart large amounts of force to a work piece. In the stamping operation, plate steel is first cut or formed into blanks of a predetermined configuration. The blanks are then placed within a press and are stamped or formed into a desired shape. For example, long pieces or blanks can be stamped into a C-shaped beam or rail. This configuration is then capable of providing greater strength when supporting or handling loads.

[0005] While stamping operations can produce components and parts in an economical fashion, several drawbacks exist. Most significantly, when stamping occurs, repeatability and consistency among parts is not always achieved. When metal is pressed into a desired shape, it tends to have an elastic characteristic causing the part to "spring back" somewhat. This spring-back characteristic is difficult to predict and is not necessarily repeatable. Consequently, high repeatability of stamped components is difficult.

[0006] Stamping operations also create inconsistencies in the work hardening of parts. More specifically, the part is "hardened" at the bend points, whereas the remaining portions of the part are generally unaffected. This results in inconsistencies in material characteristics throughout the part which can complicate the predictability of the performance of the part.

[0007] The configuration of parts is somewhat limited by stamping and bending operations. Complex parts having complicated geometries cannot always be fabricated due to limitations in the stamping process. Even when it is possible to fabricate a complex part, many separate stamping and bending operations are required to achieve the desired configuration, thus increasing costs.

[0008] A number of the parts of the frame or its components are preferably formed by generally tubular members. Tubular members are advantageous because they provide strength without excessive weight and cost and because they can easily accommodate attachment to other parts. To create tubular members and other complex geometries in a part using a stamping process, numerous individual portions of the part are typically stamped and then welded together. However, this welding process is far from ideal. Welding of numerous components requires the use of several holding or welding fixtures to configure the parts appropriately. Further, during the actual welding process, distortion is created due to heating and cooling of the parts. This distortion is very hard to control and is not necessarily repeatable, thus creating inconsistencies between components.

[0009] Mass production of stamped parts also tends to be expensive. Multiple tools are required to manufacture multiple parts. Each of these tools must be consistently designed and manufactured. The use of multiple tools complicates the manufacturing process and adds costs to the product. An additional process sometimes used for fabricating structural components is hydroforming. In the hydroforming process, a unformed part or tube is placed in a die. The interior of the tube is then pressurised causing the tube to expand to meet the interior surface of the die. By carefully configuring the die to meet the part configuration desired, tubular parts can thus be manufactured.

[0010] As is well known, the hydroforming is somewhat limited. Specifically, where wide variations in cross-section are required for the finished part, hydroforming does not provide a feasible method for manufacturing. These variations require expansion of the unformed tube at a rate or level that is typically beyond acceptable levels. Therefore, this process is not easily utilised to fabricate such parts.

[0011] The present invention uses a much different manufacturing process to formulate parts for use as var-

ious structural assemblers (e.g. brackets, frames, etc.). The process is adapted to produce consistent parts which are repeatable and consistent because little stamping and welding are used. Further, the present invention uses the process which forms tubular members having significant variations in their circumference or diameter along their length. "Tubular" as sued throughout shall describe a member that has wall that completely or substantially circumscribes an interior space, regardless of the circumferential or peripheral shape of the member.

[0012] According to this invention there is provided a method of fabricating a tubular member having a variation in circumference or diameter along its length comprising the steps of providing a blank of a predetermined shape, forming the blank into an unformed tube having a cross-section area that varies along its length, joining mating edges of the blank, placing the unformed tube within an interior cavity in a forming die, wherein the forming die has a predetermined interior surface forming the interior cavity, closing the forming die to enclose the unformed tube, introducing a high pressure fluid to the interior cavity of the unformed tube, the high pressure fluid being of sufficient pressure so as to cause the unformed tube to expand so as to come in contact with the walls of the interior cavity, thus forming a formed tube having a configuration similar to that of the interior cavity.

[0013] Conveniently the method initially comprises the step of after closing the forming die and prior to introducing a high pressure fluid, positioning a pressure ram adjacent the forming die such that a pressure opening in the pressure ram is in communication with an interior cavity of the unformed tube.

[0014] Advantageously the method further comprises the provision of a second pressure ram adjacent the forming die such that a pressure opening the second pressure ram is in communication with an interior cavity of the unformed tube, wherein the pressure ram and the second pressure ram co-operate to achieve the step of introducing high pressure fluid to the interior of the unformed tube.

[0015] Preferably the method comprises the step of stamping a blank from a sheet of material to obtain the blank of a predetermined shape.

[0016] Preferably said tube forming step yields, a formed tube having a cross-sectional area that varies more than ten percent along its length.

[0017] Conveniently the wall thickness of the unformed tube is uniform along its length and wherein the wall thickness of the formed tube is substantially uniform along its length.

[0018] Advantageously said unformed tube is frusto-conical in shape.

[0019] Conveniently said formed tube is generally frusto-conical in shape.

[0020] Advantageously a portion of said formed tube is cylindrical in shape and a portion of said formed tube is frusto-conical in shape, said cylindrical and frusto-conical portions being continuous with one another.

[0021] Preferably said formed tube includes a portion having a diameter more than 10 percent larger than the smallest diameter of said unformed tube.

[0022] Conveniently said formed tube includes a portion having a cross-sectional area more than 10 percent larger than the smallest cross-sectional area of said unformed tube.

[0023] In the process of the present invention, tubular members are manufactured using a pressurising process known as hydroforming. Typically, the process begins with a simple tube cut to a desired length. This preformed tube is selected to have a diameter that is approximately equal to the smallest diameter of the finished tube shape. The tube is then placed into a hydroforming die which is configured to completely enclose the tube. Once placed within the hydroforming die, a fluid is presented and pressurised within the tube thus causing expansion of a portion or all of the tube. Finally, the formed tube is removed from the die and is cut to the desired length.

[0024] The ability of a tube to expand under hydroforming depends upon many factors, including the material used, the wall thickness, the specific hydroforming process used, and the strength required in the resulting part. Typically, a metal tube is able to expand some reasonable amount across its diameter during the hydroforming process. Greater expansion can result in weak or thin walls in the resulting formed tube. Also, the resulting formed tube can have a fairly complex shape. That shape is limited, however, so having relatively small variations in diameter along its length if the preformed tube is cylindrical. That is, since the preformed tube must have a diameter approximately equal to the smallest diameter of the desired finished tube, and since the tube is only able to expand some reasonable amount, the resulting tube can have only limited variations in diameter between its smallest portion and its largest portion. In many applications, this variation is limited to changes of only ten percent or less.

[0025] To form a part that has significant variation in its circumference, variations in cross-sectional area, variations in gage along its length, or variations in diameter along its length, the present invention starts by forming a non-cylindrical metal tube. This non-cylindrical tube is formed by first stamping a blank from a sheet of material. The blank has a shape which, when rolled or formed so that its longitudinal edges meet, forms "a tube" having a varied diameter or circumference along its length. In one example configuration, a blank shaped like a truncated pie wedge is rolled or formed to form a frusto-conical shaped preformed tube. The resulting preformed conical tube can then be expanded by about ten percent at any desired points along its length, resulting in a finished formed tube that can have variations in diameter that exceed ten percent. In other words, by starting with a preformed tube that approximately mir-

rors the desired resulting shape, the hydroforming process can be used to create relatively complexly shaped parts that have significant variations in their diameter or circumference along their length.

[0026] The process of hydroforming is capable of better repeatability and precision in the configuration of the formed product. Consequently, a much more repeatable and efficient process is created. During the process, the metal tube is fully yielded to the configuration of the die. This eliminates the spring-back that is typically encountered in the stamping process. Further, because a more complex die can be used, the need for welding is substantially reduced and/or eliminated. Because little welding is used, the associated distortions are not encountered.

[0027] In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a top elevational view of a blank used to form a preformed tube according to the process of the present invention,

FIGURE 2 is a side elevational view of a preformed tube formed by bending, rolling or otherwise processing the blank of Figure 1 so that its longitudinal edges meet in accordance with the process of the present invention,

FIGURE 3 is an exploded view showing the hydroforming die and the preformed tube in the die's open position,

FIGURE 4 is a side elevational view of a formed tube formed according to the process of the present invention,

FIGURE 5 shows an alternate shape for a preformed blank to be used in the process according to the present invention, and

FIGURE 6 shows an alternate shape for a preformed tube for use in a process according to the present invention,

[0028] In the drawings, like numerals are used throughout to identify corresponding elements through several views.

[0029] The drawings constitute a part of the Specification and illustrate preferred embodiments of the present invention. It will be understood that in some instances, relative component and material thicknesses may be shown exaggerated to facilitate explanation.

[0030] The process of manufacturing a formed tubular member 10, like that illustrated in Figure 4, begins with a blank 15 that is stamped from a sheet of metal, such as steel, aluminum or alloy, or other appropriate material. The blank illustrated in Figure 1 is roughly shaped like a truncated pie wedge, with one end 16 being generally smaller in width than the opposite end 17. The blank 15 is generally planar and has opposite longitudinal edges 19 and 20. The blank 15 tapers gradually from its small end 16 to its larger end 17. The longitudinal edges 19 and 20 become mating edges when the blank 15 is formed about its longitudinal axis in a manner known in the art. For example, a 3 or 4 roll rolling machine can be used to roll blank 15 such that edges 19 and 20 meet.

[0031] Once the blank 15 has been formed into the desired "tube" shape, as illustrated in Figure 2, the mating edges 19 and 20 are welded together by a method known in the art that is suitable for the material of the tube, such as gas metal arc welding, high frequency welding, mash seam welding, or the like. The preformed tube 25 is generally frusto-conical shaped, tapering from a portion 28 with a small diameter to an end 29 with a larger diameter. The preformed tube 25 generally consists of a wall 30 which circumscribes an interior space 31.

[0032] Next, the preformed tube 25 is placed in a hydroforming die 35 as illustrated in Figure 3. The tube 25 is an appropriate length to fit within the hydroforming die 35. The lower half 37 and the upper half 39 of the hydroforming die 35 are then closed about the preformed tube 25. Both ends of the hydroforming die 35 are configured to have a circular opening to accommodate the insertion of a first ram 40 or a second ram 41. In one embodiment of the invention, two rams 40 and 41 are used, one positioned at each end of the hydroforming die 35. In this embodiment, the first ram 40 is inserted into the opening of the hydroforming die 35 and a fluid is injected via central orifice 45. This fluid causes all air to be flushed out of the tubular member 25. Next, while this fluid is still flowing, second ram 41 is inserted into the opposite end of the hydroforming die 35. The hydroforming die 35 and the first and second rams 40 and 41 create a closed chamber which will accommodate a high pressure cycle.

[0033] The fluid is pressurized to high pressure, causing the circular tube to expand until it meets an interior wall 50 of the die. Once this process is complete, the pressure is removed and the rams 40 and 41 are withdrawn, thereby allowing the formed tube to be removed. To remove the formed tube, the upper and lower halves of the die 37 and 39 are separated, thus opening the die 35.

[0034] As noted above, the die 35 of Figure 3 includes upper and lower halves 39 and 37. In another embodiment of the present invention, die 35 is made up of numerous sections. For example, die 35 could be configured to have four separate sections, top, bottom and two side members. The use of a multi-piece die in this embodiment is better adapted to accommodate the removal of a formed tube. More specifically, certain configura-

tions of formed tubes may tend to become lodged in sections of die 30. By using multiple sections to form die 35, this lodging or sticking can be avoided. Additionally, independent manipulation of each die section will increase flexibility during the manufacturing process.

[0035] Figure 4 illustrates a formed tube 55 made from the blank illustrated in Figure 1. The formed tube 55 includes one or more protrusions 60 in its outer peripheral surface. Generally, the shape of the formed tube 55 tapers from its larger end 63 to its smaller end 62. The shape of the formed tube 55 depicted in Fig. 4 is illustrative of the formed tubes that can be formed by the process of the present invention. It will be understood that the shape of a formed tube is dependent upon the shape of the interior wall of the die 35 which in turn is determined by the desired configuration of the resulting part. For example, a finished formed tube made according to the process described can be generally rectangular in cross-section, rather than generally circular in cross-section.

[0036] By using a preformed non-cylindrical tube in the hydroforming process, it is possible to achieve variations in the diameter of the finished tube that can exceed ten percent or whatever amount could otherwise have been achieved under the same conditions with a cylindrical tube. Further, greater consistency in the thickness of the wall of the finished tube can be achieved by starting with a preformed tube that generally or roughly parallels or mirrors the desired shape of the finished tube. Alternatively, the thickness, or gage, of the wall can be more closely controlled using the performed non-cylindrical tube described above. Consequently variations in thickness can be easily achieved.

[0037] Figures 5 and 6 show alternate examples of shapes for blanks to be used in the process described above. Figure 5 shows a blank 65 that has a first generally rectangular portion 66 adjoining a second bulging portion 67 which in turn adjoins another rectangular section 68. Blank 65 has mating edges 69 and 70 which mate when the blank 65 is formed to form a generally tubular member.

[0038] Figure 6 shows a blank 71 having a generally rectangular portion 72 adjoining a tapering portion 73. Blank 71 has opposite longitudinal edges 74 and 75 which mate when the blank 71 is rolled into a generally tubular member.

[0039] Various parameters can be used for the pressurizing operation of the present invention. For example, various pressure levels can be used depending upon the materials and configurations being obtained. The actual pressure levels used fall typically between 5,000 psi and 30,000 psi. The invention is not intended to be limited to this pressure range, however.

[0040] The hydroforming process has numerous advantages, including the elimination of many deficiencies and downfalls of previous manufacturing processes. As can be seen from the above description, each formed tube has been pressurized to match the shape and configuration of the interior die walls 50. Consequently, each product will be repeatable and consistent as the same die will be used repeatedly.

[0041] It is to be understood that even though numerous characteristics and advantages of the preferred embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and the present invention may be embodied in a variety of forms within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed. The above descriptions, therefore, are not to be interpreted as limiting, but rather as a basis for the claims and as a basis for teaching persons skilled in the art the invention, which is defined by the appended claims.

[0042] From the foregoing it will be appreciated that the preferred embodiment of the invention is a process for manufacturing and forming tubular members in a repeatable and consistent manner. This repeatability and consistency is achieved through the use of the hydroforming process. It is to be understood that the preferred embodiment of the invention is a process of manufacturing and forming tubular members having a significance variation in circumference or diameter along their length. It is to be appreciated that in one embodiment, the invention provides a process for manufacturing a part which has variations in gage along the length of a part.

[0043] A preferred embodiment of the invention is a process for manufacturing and forming tubular members having a diameter variation greater than 10 percent along their length. Preferred embodiments of the invention reduce fabrication costs in the creation of structural components. The preferred method of the invention may be used to produce repeatable, consistent parts.

[0044] In the present Specification "comprise" means "includes or consists of and "comprising" means "including or consisting of".

Claims

1. A method of fabricating a tubular member having a variation in circumference or diameter along its length comprising the steps of providing a blank (15) of a predetermined shape, forming the blank into an unformed tube having a cross-section area that varies along its length, joining mating edges (19, 20) of the blank, placing the unformed tube within an interior cavity in a forming die (25), wherein the forming die has a predetermined interior surface forming the interior cavity, closing the forming die to enclose the unformed tube, introducing a high pressure fluid to the interior cavity of the unformed tube, the high pressure fluid being of sufficient pressure so as to cause the unformed tube to expand

so as to come in contact with the walls of the interior cavity, thus forming a formed tube having a configuration similar to that of the interior cavity.

2. A method according to Claim 1 further comprising the step of after closing the forming die and prior to introducing a high pressure fluid, positioning a pressure ram (40) adjacent the forming die such that a pressure opening in the pressure ram is in communication with an interior cavity of the unformed tube.

3. A method according to Claim 2 further comprising the provision of a second pressure ram (41) adjacent the forming die such that a pressure opening the second pressure ram is in communication with an interior cavity of the unformed tube, wherein the pressure ram and the second pressure ram co-operate to achieve the step of introducing high pressure fluid to the interior of the unformed tube.

4. A method according to any one of the preceding Claims, the step of stamping a blank from a sheet of material to obtain the blank (15) of a predetermined shape.

5. A method according to any one of the preceding Claims wherein the forming die has a plurality of components (37, 39) each of which are independently positionable to form the interior cavity.

6. A method according to any one of the preceding Claims wherein said tube forming step yields a formed tube having a cross-sectional area that varies more than 10 percent along its length.

7. A method according to any one of the preceding Claims wherein the wall thickness of the unformed tube is uniform along its length and wherein the wall thickness of the formed tube is substantially uniform along its length.

8. A method according to any one of the preceding Claims wherein said unformed tube is frusto-conical in shape.

9. A method according to any one of the preceding Claims wherein said formed tube is generally frusto-conical in shape.

10. A method according to any one of Claims 1 to 7 wherein a portion of said formed tube is cylindrical in shape and a portion of said formed tube is frusto-conical in shape, said cylindrical and frusto-conical portions being continuous with one another.

11. A method according to any one of the preceding Claims wherein said formed tube includes a portion having a diameter more than 10 percent larger than the smallest diameter of said unformed tube.

12. A method according to any one of the preceding Claims wherein said formed tube includes a portion having a cross-sectional area more than 10 percent larger than the smallest cross-sectional area of said unformed tube.

Patentansprüche

1. Verfahren zur Herstellung eines rohrförmigen Bauteils mit einer Variation im Umfang oder Durchmesser entlang seiner Länge, welches die Schritte umfaßt, daß ein Rohling (15) mit einer vorbestimmten Gestalt bereitgestellt wird, der Rohling zu einem nicht-ausgeformten Rohr mit einer Querschnittsfläche ausgebildet wird, die entlang seiner Länge variiert, zusammenpassende Kanten (19, 20) des Rohlings verbunden werden, das nicht-ausgeformte Rohr in einen Innenhohlraum einer Ausformungsform (25) gegeben wird, wobei die Ausformungsform eine vorbestimmte Innenfläche besitzt, die den Innenhohlraum bildet, die Ausformungsform geschlossen wird, um das nicht-ausgeformte Rohr zu umschließen, ein Hochdruckfluid in den Innenhohlraum des nicht-ausgeformten Rohres eingebracht wird, wobei das Hochdruckfluid genügend Druck aufweist, um zu bewirken, daß das nicht-ausgeformte Rohr sich so aufweitet, daß es in Kontakt mit den Wänden des Innenhohlraums kommt, wodurch ein ausgeformtes Rohr in einer Konfiguration gebildet wird, die ähnlich ist zu derjenigen des Innenhohlraums.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, daß** es weiter den Schritt umfaßt, daß nach dem Schließen der Ausformungsform und vor dem Einbringen eines Hochdruckfluids, ein Pressstempel (40) benachbart zur Ausformungsform positioniert wird, so daß eine Drucköffnung im Pressstempel in Verbindung mit einem Innenhohlraum des nicht-ausgeformten Rohres steht.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, daß** es weiter die Bereitstellung eines zweiten Pressstempels (41) benachbart zur Ausformungsform umfaßt, so daß eine Drucköffnung des zweiten Pressstempels in Verbindung mit einem Innenhohlraum des nicht-ausgeformten Rohres steht, wobei der Pressstempel und der zweite Pressstempel zusammenwirken, um den Schritt des Einbringens von Hochdruckfluid in das Innere des nicht-ausgeformten Rohres zu bewirken.

4. Verfahren nach einem der vorangehenden Ansprüche, **gekennzeichnet durch** den Schritt des Ausstanzens eines Rohlings aus einer Materialplatte,

um den Rohling (15) mit einer vorbestimmten Gestalt zu erhalten.

5. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** die Ausformungsform eine Mehrzahl von Komponenten (37, 39) aufweist, von denen jede unabhängig positionierbar ist, um den Innenhohlraum zu bilden.

6. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** besagter Rohrausformungsschritt ein ausgeformtes Rohr mit einer Querschnittsfläche liefert, die um mehr als 10 Prozent entlang seiner Länge variiert.

7. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** die Wanddikke des nicht-ausgeformten Rohres gleichförmig entlang seiner Länge ist und daß die Wanddicke des ausgeformten Rohres im wesentlichen gleichförmig entlang seiner Länge ist.

8. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** besagtes nicht-ausgeformte Rohr kegelstumpfförmig ist.

9. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** besagtes ausgeformte Rohr im allgemeinen kegelstumpfförmig ist.

10. Verfahren nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, daß** ein Abschnitt besagten ausgeformten Rohres zylinderförmig ist und ein Abschnitt besagten ausgeformten Rohres kegelstumpfförmig ist, wobei besagte zylinderförmige und kegelstumpfförmige Abschnitte kontinuierlich ineinander übergehen.

11. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** besagtes ausgeformte Rohr einen Abschnitt mit einem Durchmesser einschließt, der mehr als 10 Prozent größer ist als der kleinste Durchmesser besagten nicht-ausgeformten Rohres.

12. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, daß** besagtes ausgeformte Rohr einen Abschnitt mit einer Querschnittsfläche einschließt, die mehr als 10 Prozent größer ist als die kleinste Querschnittsfläche besagten nicht-ausgeformten Rohres.

Revendications

1. Procédé de fabrication d'un élément tubulaire présentant une variation de sa circonférence ou dé son diamètre le long de sa longueur, comprenant les étapes consistant à prévoir un flanc (15) d'une forme prédéterminée, à former le flanc en un tube non formé présentant une surface en section transversale qui varie le long de sa longueur, à joindre les bords conjugués (19, 20) du flanc, à placer le tube non formé à l'intérieur d'une cavité interne dans une matrice de formage (25), qui présente une surface interne prédéterminée formant la cavité interne, à fermer la matrice de formage pour enfermer le tube non formé, à introduire un fluide sous haute pression dans la cavité interne du tube non formé, le fluide sous haute pression étant à une pression suffisante pour amener le tube non formé à se dilater de façon à venir en contact avec les parois de la cavité interne, formant ainsi un tube formé présentant une configuration similaire à celle de la cavité interne.

2. Procédé selon la revendication 1, comprenant de plus l'étape consistant, après avoir fermé la matrice de formage et avant d'introduire un fluide sous haute pression, à positionner un fouloir de presse (40) adjacent à la matrice de formage de façon qu'une ouverture de pression dans le fouloir de presse soit en communication avec une cavité interne du tube non formé.

3. Procédé selon la revendication 2, comprenant de plus la fourniture d'un deuxième fouloir de presse (41) adjacent à la matrice de formage de façon qu'une ouverture de pression dans le deuxième fouloir de presse soit en communication avec une cavité interne du tube non formé, dans lequel le fouloir de presse et le deuxième fouloir de presse coopèrent pour effectuer l'étape consistant à introduire le fluide sous haute pression à l'intérieur du tube non formé.

4. Procédé selon l'une quelconque des revendications précédentes, comprenant de plus l'étape consistant à emboutir un flanc à partir d'une tôle de matériau pour obtenir le flanc (15) d'une forme prédéterminée.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la matrice de formage comporte une pluralité de composants (37, 39) dont chacun peut être positionné indépendamment pour former la cavité interne.

6. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite étape de formage du tube produit un tube formé présentant une surface en section transversale qui varie de plus de 10 pour cent le long de sa longueur.

7. Procédé selon l'une quelconque des revendications

précédentes, dans lequel l'épaisseur de paroi du tube non formé est uniforme le long de sa longueur et dans lequel l'épaisseur de paroi du tube formé est sensiblement uniforme le long de sa longueur.

8. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit tube non formé est de forme tronconique.

9. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit tube formé est de forme générale tronconique.

10. Procédé selon l'une quelconque des revendications 1 à 7, dans lequel une partie dudit tube formé est de forme cylindrique et une partie dudit tube formé est de forme tronconique, lesdites parties cylindrique et tronconique étant continues l'une avec l'autre.

11. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit tube formé comprend une partie présentant un diamètre supérieur de plus de 10 pour cent au plus petit diamètre dudit tube non formé.

12. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit tube formé comprend une partie présentant une surface en section transversale supérieure de plus de 10 pour cent à la plus petite surface en section transversale dudit tube non formé.

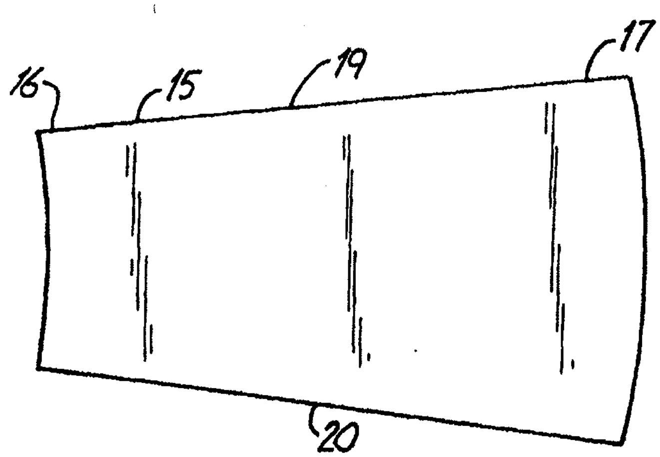

Fig. 1

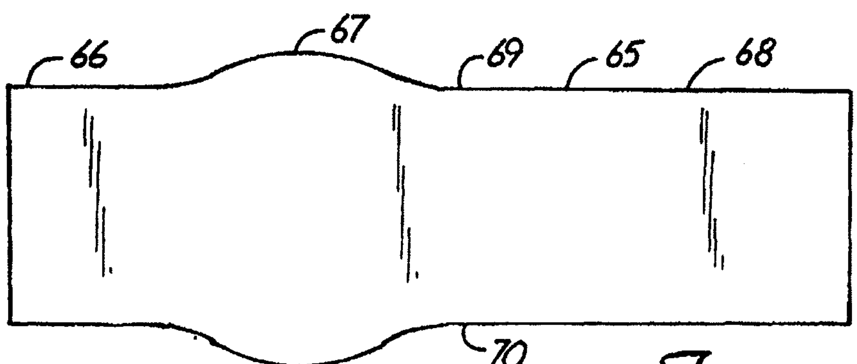

Fig. 5

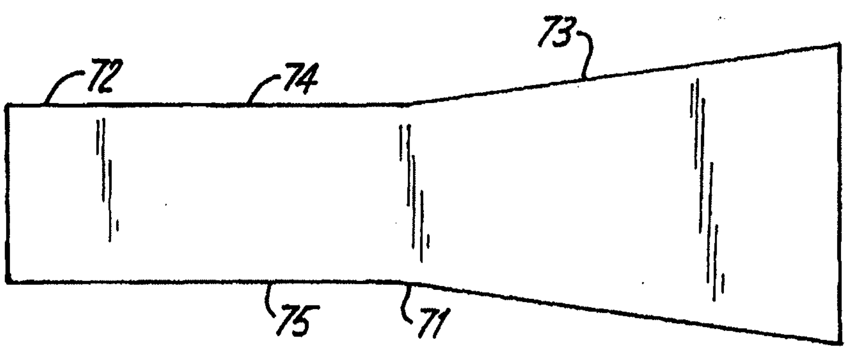

Fig. 6

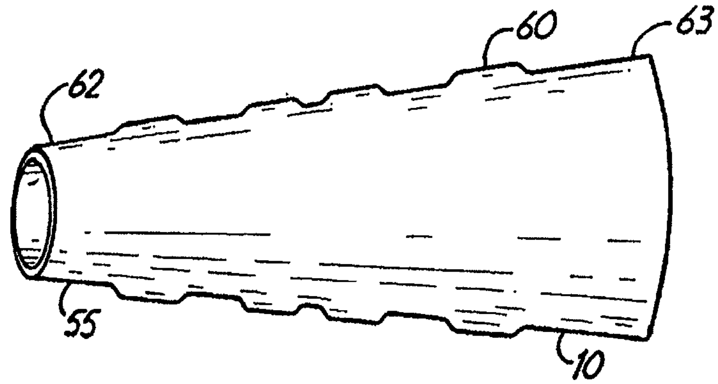

Fig. 4

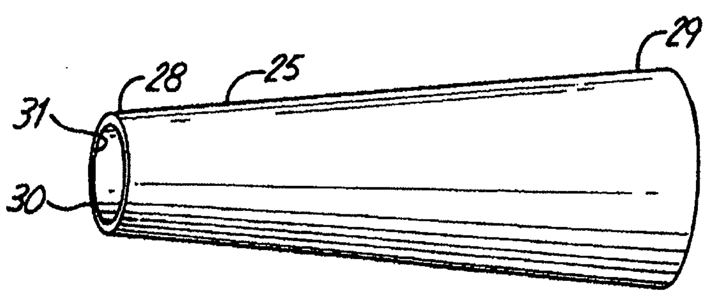

Fig. 2

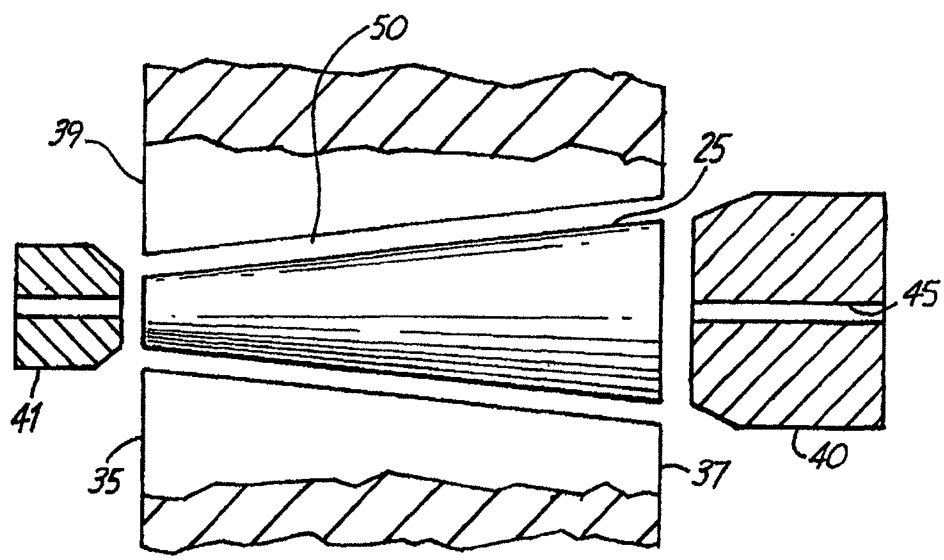

Fig. 3